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*SOIL EROSION AND ITS REMEDY BY TERRACING AND TREE PLANTING*¹

PEOPLES have the habit of visiting their heaviest penalty—death—upon those offenders who imperil the life of the community. For example, horse-stealing among cowboys, destroying bridges among the Caucasus mountaineers. By the same reasoning the time is approaching when the permitting of gullying and soil erosion will rise in our minds from waste to offense and finally to crime.

Soil erosion is an irreparable waste, perhaps the only irreparable waste, when in an age of science one considers the great possibility of substituting one substance or commodity for another. Once the soil is gone, it is gone, and can not be returned. In locations of shallow soils underlaid with rock, a very small amount of erosion throws land out of agricultural use for a geologic epoch.

Owing to our vast resources and cheap land and the scientific nature of erosion control, little has thus far been done to check erosion either prohibitively or constructively. Another reason why we have done or appreciated so little in this field is that the problem is relatively new to the Teutonic peoples.

I. FACTORS TENDING TO AGGRAVATE AND INCREASE SOIL EROSION IN AMERICAN AGRICULTURE

1. *Relation of Agricultural to Nature's Erosion Control.*—Nature controls erosion with plant roots, so that in most of the United States the problem scarcely existed before white men's agriculture began here. The beginning of agriculture here was not merely the introduction of an old-established method. American agriculture is unlike that of Europe

¹ Section I., of the A. H. A. S., has a committee on soil erosion. This committee appointed J. Russell Smith, Ph.D., professor of industry in the Wharton School of Finance and Commerce, University of Pennsylvania, a subcommittee to gather information as to the relation of tree crops to the erosion problem. This paper presented at the 1913 meeting of the section is the result of journeys of investigation in the Mediterranean countries and islands and in central and southern United States.

and far more deadly as a promoter of erosion. European agriculture has but little bare ground, most of the crops covering the entire surface of the ground and holding it with a root mass, as does wheat, barley, clover. America has added to the European agriculture the three great bare-ground crops of corn, cotton and tobacco. The tillage of these crops prepares the ground for erosion. The soil is kept bare, loose and soft. Frequent cultivations gash it ready for the starting of the digging rills of running water when a storm comes.

2. *The New and Erosive Type of Rainfall.*—Another factor, new to the Caucasian race, is a heavy summer rain which exists in all the territories growing these three crops, and comes in the peculiarly destructive form of a thunder shower, with its tremendous powers of eroding loose bare soil.

3. *The Increasing Area of Erosion-inducing Crops.*—The increasing demand for these bare-ground crops tends more and more to make us cultivate and destroy hilly lands which, while in good pasture or forests, erode but little.

II. FACTORS IN EROSION CONTROL

1. Deep plowing has been extensively recommended by our agricultural authorities, but casual observance of hill lands almost anywhere shows it to be but a partial remedy, and corn and cotton fields under the best recommended deep plowing can often be shown to be eroding at rates that are completely ruinous if kept up for any long period.

2. Contour plowing tends to diminish erosion, but this device is hostile to the American system of farming that is characterized by the utilization of machinery sweeping in straight lines over large areas.

3. Terracing has been quite widely used in the south, but usually in a relatively inefficient way because in effect it chops a field up into a multitude of small fields of irregular shape. Between these little patches are untilled banks that grow weeds instead of crops. We have, however, the recent discovery of the Mangum terrace worked out by a farmer at Wake

Forest, N. C., and now adopted by the Federal Department of Agriculture. It is a great improvement over any terracing to be found in either Europe or America. It consists of wide gentle ridges plowed up along the face of the slope so that the water flows slowly and harmlessly along it, while its wide gentle slope permits the planting of crops and the utilization of agricultural machinery directly across it at the same time that it controls the run-away waters. There is almost no washing of earth where the system is maintained, and the ground is fully utilized in the American way.

A proper appreciation of the economic and far-reaching importance of soil saving should bring us in a short time to a point where, by compulsion or premium, all tilled lands liable to washing would be handled by this method or some other equally efficient one.

4. Plowless utilization of land offers great possibilities for the checking of erosion and the vast increase of our crop area.

(a) *Forestry and Pasture*.—Thus far tree planting in the form of forestry has been almost the sole panacea, other than pasture, for steep lands. The fruitlessness and slowness of a forest, which yields its one crop in from twenty to one hundred and fifty years, is a profound objection to it as a resource for the owner of the average small farm. The yield of hill pastures is too small to be a satisfactory dependence. Therefore, we have plowed, gullied and destroyed.

The inefficiency of pasture is indicated by its almost entire elimination in the arable areas of western Europe where it has given away to tilled crops. Its inefficiency in comparison to tree crops is shown by the fact that the pounds of food, the income and the nutrition produced by an acre of good sheep pasture in England are less than that produced by a good walnut tree in France.

(b) *Crop Trees*.—The tree is nature's real engine of production. This scientific fact seems to have been overlooked, despite the great value that trees have been to us. By a spasmodic and chance development, the tree has given us a number of valuable tree crops. The land that is in harvest-yielding trees is

usually the heaviest yielding and most valuable land. Witness the orchards everywhere. The king of all crops, as measured by the greatest amount of food produced and the value of the land, is a tree crop—the date.

Past development of tree crops has come peculiarly by chance. Now that we know how to breed plants, we need the systematic examination of all the trees of the country with regard to their present or potential crop possibilities. This is a task requiring much work and having tremendous promise of increased national wealth. This conclusion is borne out by the facts now known concerning American trees, and by the occasional development of tree agriculture both in this country and in Europe.

In this country while we have an extensive fruit industry, it has touched but a small corner of the possible tree-crop field, and the crops have been limited chiefly to those fruits that may be classed as succulents rather than nutrients, and they have been limited also to human food rather than to forage. Forage is the great demand upon the American farm. The animals eat several times as much as we do.

1. *Tree Forage*.—Forage tree crops in Europe, Africa and Hawaii, are suggestive of great developments in America. The carob bean, worth about one cent per pound at the farm, is a much prized nitrogenous and also carbohydrate stock food widely grown from Gibraltar to Palestine, and exported to England and to some extent to the United States. In Hawaii we have its counterpart, the mesquite bean, a bran and cornmeal substitute, rapidly becoming an important industry. The yields reported by the Hawaiian Experiment Station are almost staggering in their significance. Mesquite forests on rough untilled and untillable land are producing from 4 to 10 tons of beans per acre and the bean meal sells at \$25 a ton. We have in the United States, waiting to be developed, similar leguminous, cropping trees growing from the Pacific to the Atlantic in the form of the mesquite in the west and the honey locust in the east, both great bean-yielding trees.

The European utilization of the acorn as swine food amounts to millions of dollars annually, and while we have some hundreds of thousands of hogs using the bought privilege of eating the acorns of our national forests, no one seems to have seriously considered the possibility of investigating the American oak as a corn substitute, yet there is good reason to believe it may be more effective than corn in many localities. American trees yielding several hundred pounds of acorns are common.

The utilization of the fig in Majorca and Portugal gives us added reason to contemplate the great possible service of mulberries and persimmons as automatic pig feeders, the crop being harvested by the animals themselves. The extensive use of the chestnut as a corn forage substitute in the mountainous parts of Italy, Corsica and France shows us what we might do in Appalachia with native or imported chestnuts, and also with hickories and other native nut trees.

2. *Major Foods from Tree Crops.*—The great dietary wants of man are proteid for tissue, carbohydrate and fat for energy. None of these wants has been met to any important extent by a tree crop in the United States. The proteid demand is substantially met in Europe by the use of the walnut, almond and filbert. Unquestionably the native and Persian walnuts of the United States, along with that remarkable tree, the pecan, and the numerous native hickories and hazelnuts, offer us great possibilities of new and extended industries and new staple food supplies.

The carbohydrate tree crops of the Old World are even more important than the proteids. The date (more nutritious than bread) is the main stay of vast areas, and the fig (even more nutritious than the date) is also a great food. The chestnut is, to large areas of Spain, France, the Mediterranean islands, and Italy, the same thing that corn is to the Appalachian mountaineers—a great starch food. The acorn, with an analysis much like that of wheat, excepting a shortage of protein, has for ages been a food for many Mediterranean peoples, and holds out at any time the possibility of being made into a very accepta-

ble farinaceous food for the American people if they should choose to develop it, in an age of science and factory-prepared foods. Fat is furnished in Europe by the olive to so great an extent that the olive covers a larger proportion of Spain than wheat does in the United States. We have not yet developed an oil industry, although the resources are at hand.

3. *Areas and Adjustment.*—The tree is plainly our best means of utilizing steep and rough land, and if we can develop means of utilizing the cropping tree without the plow, we can easily double the crop area of the United States. At the present time tree crops cover only about one fiftieth of our agricultural area, when they apparently possess the possibility of covering half of it with great profit and with a permanence of production now unknown.

The example of a thousand per cent. increase in value of a Corsican hillside when well established in chestnut orchards that have never been plowed and which have produced for centuries, is exceedingly suggestive.

The problem is not merely a problem in forestry, for it is an established fact, that the fruiting trees must have sunshine on all sides. Numerous modifications of the forestry situation, however, suggest themselves. Tall trees like the pecan might be surrounded by coppices of leguminous trees like the locust, which might attain salable size, and by their nitrogenous roots greatly enrich the soil, as is the case where certain leguminous trees are grown with coffee. Crop trees like the pecan and walnut, persimmon or mulberry might be surrounded by thickets of bush size legumes, which absolutely maintain the soil against erosion, which enrich it, and which might be annually cut in the place of being annually plowed, or they might be pastured once a year with goats, and thus kept under control, made to render their service to the crop tree, and still give some value as forage.

4. *Moisture and Fertility Control.*—American agriculture is unquestionably suffering from too great a conviction that cultivation

is essential to the preservation of moisture and the supplying of fertility.

There is little doubt that the earth mulch, a preparation for erosion, does make the fertility more available, and does check evaporation. We need much more knowledge than we now have as to whether or not the same results may not be obtained by the application of mineral or other chemical fertilizers, which will increase natural vegetation, which will therefore increase humus, and the natural water-holding power of the soil. Rather convincing evidence as to the efficacy of this latter method is to be had in the sod mulch orchards under the care of the Ohio Agricultural Experiment Station, and also in the variation of crop yields in rich and poor lands in a dry season in the Berber villages of Northern Algeria. At the present moment the idea of the maintenance of fertility and a good crop yield without tillage is so unorthodox that almost no experiment stations in the United States will look at the subject with respect, yet in it lies great possibility of the extension of tree-crop agriculture to large areas of land where cultivation is difficult and is almost synonymous with erosion unless careful terracing shall be worked out.

The actual holding of water upon the ground until it sinks in is an aspect of the matter well worthy of extensive investigation. The manguum terrace, which is so efficient in taking water away from a hillside without erosion, can doubtless be enlarged and made absolutely horizontal so that it will keep the water where it falls, after the practise of Colonel Freeman Thorpe, of Hubert, Minnesota. This is a practise worthy of much experimentation, and one which fits peculiarly into the tree-crop idea. It is doubtless true that in many localities the water standing behind the horizontal manguum terrace would injure wheat, clover and other small crops. On the other hand, there seems to be little reason to anticipate that it would injure trees that stood upon the terrace and had their roots beneath the reservoir of water, which might stand and freeze for considerable periods with no injury to the tree, which would get the water when it soaked

into the ground. This has been proved successful for 20 years in a Pennsylvania apple orchard.

This practise has been worked out for many decades in the olive orchards of Central Tunis around Sousse, and it unquestionably can be utilized with tree crops in many parts of the United States. Its limitations must be defined by experimentation, which may also find aids in the growth of deep-rooting annual plants to increase porosity and absorbing power of the soil.

There also appears to be no reason why this manguum terrace might not be modified into a series of basins that would hold near each tree the water that fell near it, and thus practically apply the methods of the California water economizing irrigators. Such preparation of the soil would be effective for many years and would therefore be less expensive than annual cultivation.

An effect of this holding of water where it fell would be the absolute stoppage of a loss of fertility that results from the washing away of incrustations of soluble salts deposited through the evaporation of earth moisture at the surface. The effectiveness of this process in bringing earth salts to the surface is well known. It has given us our alkali soils, but we owe it to Colonel Freeman Thorpe to call our attention to its surprising effectiveness as an agency in fertility loss where water is allowed to run off of the surface. This factor alone may be found worthy of all the effort necessary to hold water where it falls.

III. CONCLUSION

If the economic botanists and plant breeders can give us a series of new cropping trees which will furnish new foods for both man and beast, we will have an economic factor which will combine a number of forces, because it helps to meet a number of needs. It will greatly stimulate food production, also wood production. Through the development of the plowless agriculture and terrace water holding, we will have conservation of the soil and of fertility. We will also have in this combination the greatest of all forces yet

brought to bear upon the problem of flood control, and also a great aid to navigation and irrigation, because of the better conservation of water in the soil for springs and streams.

It is a problem with which the individual farmer of an intellectual turn of mind can experiment in a small way, but above all it is one which needs, even demands, the attention of the federal government and many of the agricultural experiment stations.

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*THE MASSACHUSETTS INSTITUTE OF
TECHNOLOGY AND THE STATE*

IN an address at the annual banquet of Technology alumni in January, Governor Walsh suggested a closer cooperation between the institute and the state. The result has been, in its successive steps, the appointment of a special committee to consider the matter by Jasper Whiting, president of the alumni association, a conference with the governor in March, an investigation of all the sources of information and a report to the alumni council on May 25. The latter while it has naturally been based on the institute and its resources proves to be so broad in its applications that there is place in the plan for all the institutions of the state that can give advice. "When they are so harnessed to the state's interest," the report reads, "they will constitute a great state university geographically diversified, possessing the momentum of valuable traditions, the strength of long years of experience and moral influence through their great alumni bodies—all this making of them units, which if assimilated by a wise state policy will form a coordinated system of educational facilities, which in its broadest sense is a university."

First there is recommended legislation which shall increase and regularize the services of members of the faculty of the institute (and other institutions, to be specified in the act) on state boards and commissions, either as members or in an advisory capacity. Such legislation should be applicable to all state commissions which conduct work requiring

scientific or technical skill or advice. Suggestions for direct payment for such services direct to the institution are made, since it is best fitted to apportion such payments between individual service and the use of the laboratories of the school.

The second recommendation is that the use of the laboratories and shops of the institute be placed at the service of the state under appropriate conditions which will safeguard the educational purpose of the institute and the administrative needs of the state. No direct charge should be made for the use of these laboratories, but the state should bear the expenses of labor and material plus a fixed sum to be added to cover wear and depreciation. Provision should be made for an equitable adjustment of this charge.

For its third suggestion the committee advises the establishment of a bureau of technical information, which shall without charge furnish to the state and the public, advice which may be obtained without substantial expense, either in furnishing ordinary scientific information or indicating the lines of inquiry to be followed.

The committee recommends the appointment by the governor of a permanent committee on cooperation to carry into effect these recommendations, to study further the needs of the state as to closer cooperation between it and the institute and additional means of making such cooperation effective. Such a committee would also look forward to a system of cooperation between the state and the various other educational institutions.

The committee finds that from its inception the Massachusetts Institute of Technology was intended to serve the scientific needs of the state and its people. Its charter looks to aiding the advancement, development and practical application of science in connection with the arts, agriculture, manufacture and commerce. In this department of its activities the committee finds momental achievements to the credit of Tech in many different divisions of work. In fact the whole history of the institute shows that the institute has given to the state and that the state has drawn freely from